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CHILD DEVELOPMENT

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CREATININE EXCRETION, GROWTH PROGRESS AND BODY STRUCTURE IN NORMAL CHILDREN

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It is generally agreed that the amount of creatinine excreted per 24 hours increases in the urine of human individuals from birth to maturity. Furthermore, following the concepts of Folin (1, 2, 3), it is widely accepted that the creatinine excretion rate is higher in a large, muscular individual than in a thin, non-muscular individual of the same height. Even though there is some disagreement as to the magnitude of daily variation, there does appear to be a creatinine excretion rate which is more or less characteristic for the individual.

The factors which regulate the creatinine excretion rate are still a matter of dispute, as can be seen by reference to recent reviews, including Hunter (4), Wang (5), Beard (6), Vague and Dunan (7), and Rose (8, 9). Among such factors have been mentioned diet, age, sex, muscle mass, energy production rate, endocrine activity, and the metabolic characteristics of individual muscles. Practically speaking, one has to add to this list the sources of error encountered in collecting 24-hour urine samples, particularly on children.

The present study is based on an analysis of approximately 400 creatinine determinations, taken on 155 Fels Institute children in the spring and fall of 1945, and the fall of 1946. Ages range from 3 to 17 years. Seventy-six children have determinations for all three periods studied, and 60 have determinations for two of the periods. In a number of instances, duplicate determinations were made.

From the data on physical growth available on each child, the following items were selected for association with the creatinine values: sex, age, height, weight, surface area, and calories per 24 hours. In a selected series, to be described later, additional measurements were made of the breadth of bone, muscle mass, and superficial fat, as seen in the roentgenogram of the leg (10, 11).

The object of this paper is to present norms for creatinine excretion during the period of childhood studied, and to relate creatinine excretion to the physical variables mentioned above. Values for creatine, determined on these same children, will be discussed in a later paper, together with an analysis of creatine-creatinine relationships. This study is the first of a

series, relating the more usual physical measurements of human growth to the variables derived from an intensive biochemical program now underway at the Fels Research Institute (12).

Materials and Methods

Urine Collection. The 24-hour samples were collected at the subjects' homes, under the supervision of parents in the case of the younger children. The reasons for collection of the samples were carefully explained, and a printed sheet of directions was given with each collection bottle.* The subjects, or their parents, kept a record of the details of collection on a special form provided (Figure 1). The cooperation of the donors was facilitated by the gift of a shiny new silver dollar for each sample collected.

Samples were repeated if analysis showed them to be more than ± 1.75 sigma from the mean for the creatinine/body-weight ratio for the entire series. Most of the repeat values were very close to the original determination, and the mean difference between the originals and the repeats, as measured by the creatinine/body-weight ratio, is less than 1 unit. We feel that the samples collected are, in general, quite accurate, since the families are the regular voluntary participants in the Fels program of longitudinal growth research (13).

The glass-stoppered collection bottles contained 100 ml. of dilute (10 ml. of concentrated hydrochloric acid + 90 ml. of water) acid as a preservative. The samples were collected promptly, and refrigerated immediately upon arrival at the laboratory, and after dilution to 2 liters, aliquots were analyzed for creatinine, creatine, 17-ketosteroids and other compounds.

Method of Determination. The creatinine determinations were made using the Folin (14) alkaline picrate method, but modified so that the entire procedure could be conducted in a 30 ml. test tube. The picric acid was

*Directions for Collecting a 24-Hour Urine Sample read as follows:

Definition: A 24-hour sample contains the metabolic products, or "waste products," for exactly 24 hours of body activity.

Collection: Upon rising in the morning, empty the bladder, and record the time *accurately* in the space provided on the Record Sheet, but *do not* collect the urine. From this time on, *up to and including the following morning,* collect all of the urine in the bottle provided. Record the time of each urination on the Record Sheet, attached to the bottle.

Preservation: The bottle you have contains a small amount of weak acid which acts as a preservative. It is desirable to *keep the bottle in a cool, dark place* until it is called for.

Records: You are a member of the biochemistry research staff while collecting the urine. It is essential for the accurate determination of vitamins and hormones that a 24-hour sample be obtained and that all the times be carefully recorded on the Record Sheet. If part of the sample is accidentally lost, record the time and approximate amount; it will usually be necessary to collect an entirely new sample later.

RECORD SHEET

TWENTY-FOUR HOUR URINE SAMPLE

SAMUEL S. FELS RESEARCH INSTITUTE — BIOCHEMISTRY DEPARTMENT

Name _____ (First / Middle / Last)

Birth Date _____ Sex _____

Date Collection Started _____

Date Collection Finished _____

PLEASE RECORD ALL TIMES TO THE NEAREST MINUTE

RECORD OF URINATION TIMES

First Morning Sample DISCARDED at _____ (Time)

Sample No.	Time Collected	Sample No.	Time Collected
1		9	
2		10	
3		11	
4		12	
5		13	
6		14	
7		15	
8		16	

RECORD OF MEAL TIMES

Meal	Time
Breakfast	
Lunch*	
Supper	
Breakfast	
Between meals	

Have you taken any medicine or vitamin supplements during the week preceeding this collection? YES ☐ NO ☐

If YES, what and how much? _____

*Vitamin test dose taken at _____ (Time)

Figure 1. Record Sheet for 24-hour urine sample.

recrystallized several times from acetic acid until it passed the purity test of Folin and Doisy (15). The saturated picric acid solution recommended by Folin was replaced by a 1.175 percent solution, following the suggestion of Peters (16). Further details of the procedure, along with an improved method for measuring creatine, will appear in a later paper.

The Physical Measurements. Standing height and total weight were taken on the child without clothes, and age was recorded to the nearest month. Surface area was calculated from the Dubois body surface chart, as prepared by Boothby and Sandiford (17). Calories per 24 hours were calculated from the oxygen consumption as measured on the Jones motor basal metabolism machine, using the following formula:

$$\frac{1440 \text{ minutes}}{\text{time of test in minutes}} \times 4.825 = \text{total 24-hour calorie output}$$

The value 4.825 represents the calories in 1 liter of oxygen.

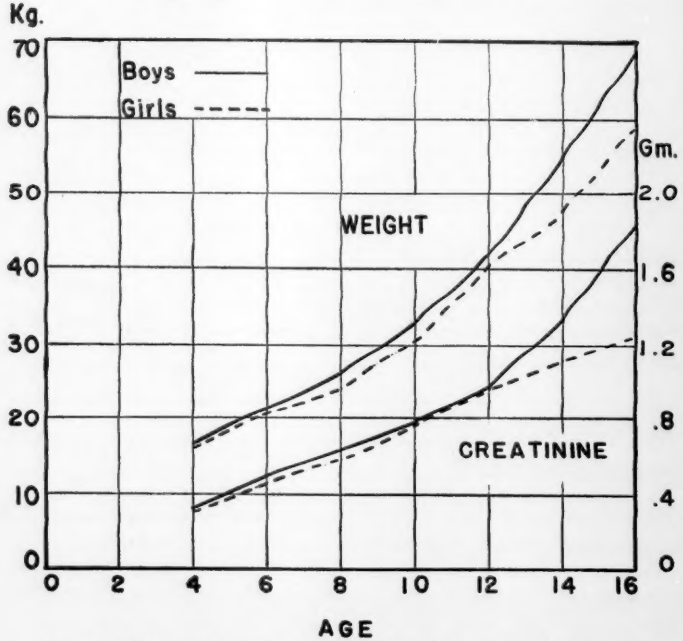

Figure 2. Mean values for body weight and for creatinine excretion per 24 hours. Each biennial entry covers an age-span of a year on either side; thus, entries at 4 years represent the means of values from 3.0 through 4.9 years.

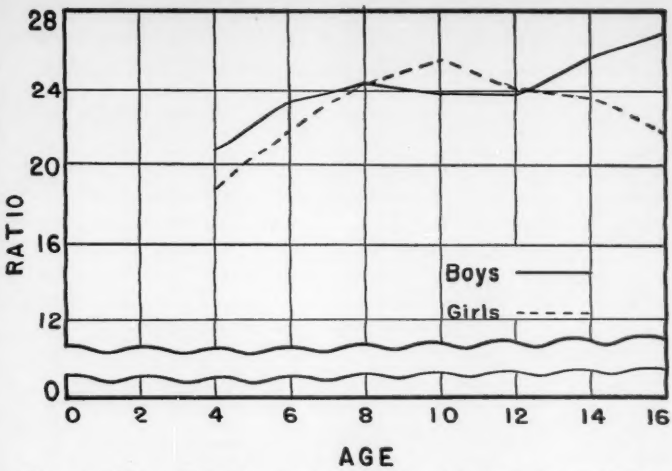

Figure 3. Mean values for creatinine/body weight ratio, or creatinine coefficient: the mg. of creatinine excreted in 24 hours per kg. of body weight.

Results

Norms and Sex Differences on the Total Series. In Table 1, norms are given for body weight, creatinine excretion per 24 hours, and the creatinine/body-weight ratio. The last value, known also as the creatinine coefficient (18), represents the 24-hour excretion of creatinine in milligrams per kilogram of body weight. Results are shown graphically in Figures 2 and 3.

Mean body weight, in the present sample of children, is not representative, at the upper age levels, of the Fels population as a whole (19). This is due to the inclusion of a number of larger than average boys, and a number of smaller than average girls, at the upper age levels. For this reason, the weight curves shown in Figure 2 do not show the higher mean values for girls usually seen in the early teens. Since the present study is concerned, not with weight as such, but with the relation of weight and other physical variables to creatinine excretion, the skewed distribution of weights does not affect the present analysis.

Creatinine excretion, as seen in Figure 2, shows a pattern very similar to weight, the mean values for boys being larger at all age-levels, and showing a considerable increase from 13 years on. The following coefficients of correlation were obtained:

Creatinine excretion and weight,	375 cases:	$r = +.89 \pm .01$
Creatinine excretion and height,	392 cases:	$r = +.75 \pm .02$
Weight and height,	399 cases:	$r = +.91 \pm .01$

TABLE 1

Boys

Age	No.	WEIGHT (Kg.)		CREATININE (Gm.)		CREATININE / WEIGHT RATIO	
		Mean	*Sigma*	*Mean*	*Sigma*	*Mean*	*Sigma*
3 - 4.9 Years	17	16.64	1.37	.33	.07	20.9	5.7
5 - 6.9 Years	31	21.27	3.28	.49	.13	23.3	7.3
7 - 8.9 Years	29	26.18	2.82	.64	.21	24.4	7.9
9 - 10.9 Years	27	32.74	4.89	.78	.20	23.9	5.1
11 - 12.9 Years	27	41.88	9.40	.98	.30	23.4	4.5
13 - 14.9 Years	24	54.68	12.64	1.33	.32	25.6	5.2
15 up	23	68.87	9.48	1.85	.30	27.0	3.4
		Girls					
3 - 4.9 Years	18	16.38	1.88	.31	.07	18.9	4.4
5 - 6.9 Years	25	20.59	2.95	.46	.13	21.9	4.3
7 - 8.9 Years	34	24.31	3.18	.59	.13	24.4	5.7
9 - 10.9 Years	33	30.62	4.68	.77	.20	25.5	7.1
11 - 12.9 Years	41	40.47	7.80	.97	.27	24.2	5.6
13 - 14.9 Years	26	47.63	8.94	1.11	.22	23.6	3.7
15 up	18	59.20	13.07	1.26	.16	21.9	4.2

When expressed in terms of partial correlation:

Creatinine excretion and weight (holding height constant) $= +.76$
Creatinine excretion and height (holding weight constant) $= -.32$

The creatinine/body-weight ratio, Table 1, shows for the boys a rise in relative creatinine excretion from 20.9 to 24.4 between 3 and 8 years, a level pattern for the next 4 years, and an increase from 23.4 to 27.0 between 12 and 16 years. The values for the girls rise from 18.9 at 4 years to 25.5 at 10 years, at which level they show a higher mean ratio than the boys. From 10 years through the remainder of the period studied, the means for the girls fall steadily, and at 16 years show a value of 21.9. See Figure 3.

The percentage distribution of creatinine/body-weight ratios for the entire series is shown below, without regard for age or sex:

Ratio	*Percent*
10.0 – 13.0	1.6
13.1 – 16.0	3.8
16.1 – 19.0	12.7
19.1 – 22.0	21.7
22.1 – 25.0	28.7
25.1 – 28.0	16.8
28.1 – 31.0	7.3
31.1 – 34.0	2.9
34.1 – 37.0	2.4
Above 37.1	1.8

Two-thirds of the cases (67 percent) show ratios between 19.1 and 28.0. Less than 10 percent show values of less than 16 or more than 34. The highest ratio recorded was 55.

The distribution of maximum differences in the creatinine/body weight ratio, for the 136 children having more than one determination, is shown below:

Maximum Difference	*Percent*
0 – 1.5	13.2
1.6 – 3.0	16.2
3.1 – 4.5	16.2
4.6 – 6.0	16.9
6.1 – 7.5	11.8
7.6 – 9.0	6.6
9.1 – 10.5	7.3
10.6 – 12.0	2.2
12.1 – 13.5	2.2
Above 13.6	7.3

Almost three-fourths of the group (74 percent) show maximum differences of 7.5 or less, between ratios obtained on an individual at one period and a period six months or a year later. Around 7 percent show maximum differences of more than 13.5.

In Table 2, creatinine excretine is considered in terms of weight groups, without regard for age-level. Creatinine per kilogram of body weight shows little sex difference until the weight passes 40 kilograms, when the boys have an increasingly larger creatinine excretion for their weight. See Figure 4.

The Special Series. For the purpose of further analysis a smaller group was selected. The 25 children showing the greatest consistency in the creatinine/body weight ratio, on repeated determinations, were used. Ten boys and fifteen girls fell into this group, and represented 66 determinations. Sex differences for a number of variables are shown in Table 3.

TABLE 2

CREATININE (GM.) BY WEIGHT GROUPS

Weight Group (Kg.)	BOYS			GIRLS		
	No.	*Mean*	*Sigma*	*No.*	*Mean*	*Sigma*
10.0 - 19.9	29	.39	.14	32	.33	.08
20.0 - 29.9	57	.59	.18	67	.63	.18
30.0 - 39.9	32	.83	.20	37	.85	.15
40.0 - 49.9	18	1.08	.21	29	1.04	.24
50.0 - 59.9	15	1.44	.23	23	1.24	.23
60.0 - 69.9	13	1.66	.24	5	1.30	.10
70.0 up	14	1.95	.34	3	1.36	.09

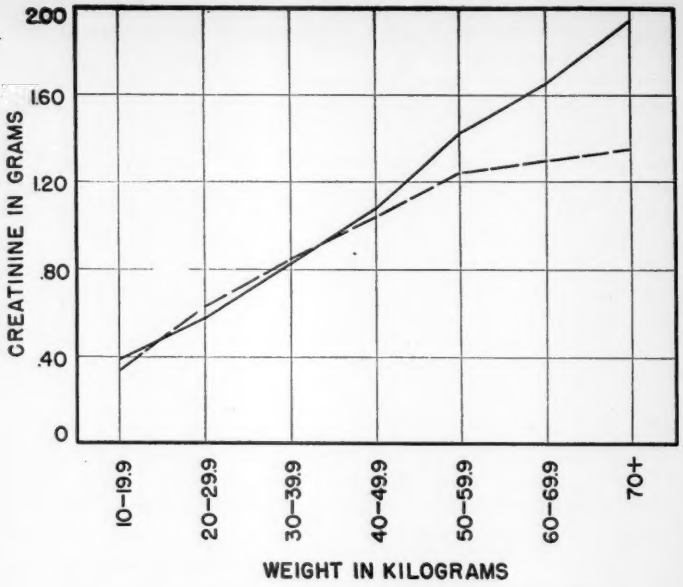

Figure 4. Mean values for creatinine excretion per 24 hours by weight, disregarding age.

The boys are, on the average, 8 months younger, 1 kilogram lighter in weight and 2 centimeters shorted in height, with a correspondingly smaller mean surface area. The mean creatinine excretion, however, is larger (1.033 grams to .861 grams for the girls), and the creatinine coefficient is accordingly greater. Calories per 24 hours is higher for the boys.

In order to relate creatinine values more directly to body structure, measurements were made on this group of the breadths of fat, muscle and bone in the calf, as seen in the roentgenogram of each subject. Techniques of measuring such tissue breadths have been described in previous papers (10, 11).

Slightly smaller than the girls in mean total breadth of calf, the boys show a relative breadth of fat which is smaller, and a relative breadth of bone which is larger, than corresponding values for the girls. These differences are in the expected direction, as is the slightly larger relative muscle breadth for the boys. In Table 4, intercorrelations of creatinine excretion, age, weight, height, muscle breadth, fat breadth and bone breadth are shown.

TABLE 3

COMPARISON OF MEAN VALUES FOR 25 CHILDREN SHOWING LEAST VARIABILITY IN CREATININE/BODY WEIGHT RATIOS

ITEM	*BOYS* (N=10)*	*GIRLS* (N=15)
Age	128 months	136 months
Creatinine	1.033 grams	.861 grams
Creatinine Coefficient	23.8	20.9
Weight	41.32 kg.	42.32 kg.
Height	143.5 cm.	145.8 cm.
Tissue Breadths:		
Total Breadth of Calf	99.0 mm.	100.3 mm.
Breadth of Fat	13.8 mm.	17.3 mm.
Breadth of Muscle	54.2 mm.	54.2 mm.
Breadth of Bone	31.0 mm.	28.8 mm.
Relative Breadth of Fat	14%	17%
Relative Breadth of Muscle	55%	54%
Relative Breadth of Bone	31%	29%
Calories per 24 Hours	1545 calories	1343 calories
Surface Area	1.255 square m.	1.285 square m.

*Means for the 10 boys represent 26 examinations; means for the 15 girls represent 40 examinations.

All values are statistically significant at the 1 percent level. Fat breadth shows the lowest association, both with the other two tissue breadths, and with the other variables. When the coefficients for the three tissue breadths are examined, partial correlations are as follows:

Muscle and bone (with fat held constant): +.72
Muscle and fat (with bone held constant): +.20
Bone and fat (with muscle held constant): +.17

Fat breadth, therefore, shows little association with either muscle or bone breadth, when the effect of the other tissue breadth is removed. The association of muscle and bone breadths changes only slightly (from +.78 to +.72) when the effect of fat breadth is removed. Since the r between fat

TABLE 4

INTERCORRELATIONS (r) OF 7 VARIABLES ON 25 CHILDREN SHOWING LEAST VARIABILITY

	(2)	(3)	(4)	(5)	(6)	(7)
(1) Creatinine	+.90	+.88	+.88	+.82	+.42	+.93
(2) Age		+.91	+.96	+.59	+.59	+.90
(3) Weight			+.90	+.91	+.65	+.89
(4) Height				+.86	+.53	+.86
(5) Breadth Muscle					+.46	+.78
(6) Breadth Fat						+.47
(7) Breadth Bone						— —

breadth and creatinine is low (.42), fat thickness, as here measured, does not appear to be an important factor in creatinine excretion, and attention may properly be devoted to examining the relations of the other two tissue breadths.

An examination of Table 4 shows that both bone breadth and muscle breadth are highly associated with creatinine excretion. Bone breadth, however, shows the larger coefficient, in this small series of cases, than does muscle breadth. This higher association between bone breadth and creatinine seems to derive from the fact that there is a higher r between age and bone (+.90) than between age and muscle (+.59). When the effect of both age and each of the two tissue breadths in turn is removed by partial correlation, the following values are shown:

Creatinine and muscle (with age and bone held constant): +.68
Creatinine and bone (with age and muscle held constant): +.14

The problem of the relationship of creatinine excretion to muscle was approached in another manner, by a selection of two groups of children, who through clinical inspection were rated as "muscular" and "non- muscular." Ten children, representing 25 determinations, were in the former group, and 14 children, representing 42 determinations, in the latter group. The muscular group had a mean creatinine/body weight ratio which was significantly higher (26.5) at the 1 percent level, than the mean ratio for the non-muscular children (22.6).

The association between creatinine excretion and surface area was examined in terms of the correlation coefficient (r). The coefficient was high, +.91, and this same value was obtained when creatinine excretion was correlated with calories per 24 hours.

Discussion

It is not within the scope of this paper to summarize in any comprehensive fashion the very large literature on creatinine research. In general, our calculations for the creatinine/body weight ratio (creatinine coefficient) agree with those previously reported. Wang, Genther and Hogden (20) found the coefficient to range from 19.5 to 26.4, with an average of 22.8, in 23 adolescent girls. Talbot (21) reports a range of 15.3 to 27.5, with an average of 20.5, in a group of normal children between the ages of 5 and 12 years. He found an average of 14.0 in obese children, 30.7 in lean (muscular) children, and 9.0 in emaciated children.

Miller (22) shows means for boys from 19.5 to 28.6, between 7 and 15 years, while the girls in his series range between 18.9 and 20.8 during this same period. Our findings confirm this indication of a sex difference in the creatinine/body weight ratio at adolescence, with a sharp rise showing for boys only, around the age of 13.

Along with Miller, Talbot (21), Hodgson and Lewis (23), Brody, Proctor and Ashworth (24), Day (25), and others, we believe that creatinine

output is directly related to growth of muscular tissue, and that the sex differences shown are associated with sex differences in muscle development during the period of rapid sexual maturation. Recent reports by Jones on the relation between strength and sexual maturation in boys (26) and girls (27) lend support to this view. Jones' series show an increasing divergence in mean scores for grip strength during the second decade of life. At 11 years, the right hand grip strength for boys averages 24 kg., for girls, 21 kg. At 17.5 years, the mean for boys is 56 kg., with a sharp increase in the curve at 13 years. For girls the mean at 17.5 years is 38 kg., with no corresponding break in the curve.

We are now accumulating data on children at higher age-levels, on adults, and on children and infants below the age of 3 years. Previous work (18, 28, 29) has indicated that the average creatinine/body weight ratio ranges from 20 to 26 in normal men, and from 14 to 22 in normal women. Everett (30) gives 24 ± 8 for men, 18 ± 9 for women, 12 ± 4 for children, and less than 8 for infants. What data we now have indicate a rather marked drop in the ratio below the age of 4. Catherwood and Stearns (31) found an average value of 12.5 for infants up to the age of 1 year.

An analysis of 150 additional urine samples, collected on Fels Institute children in the fall of 1947, agrees very well with the results reported in this paper. These data are being incorporated with the present material in a more extensive report.

Summary and Conclusions

Results are given of an analysis of 400 creatinine determinations on 155 Fels Institute children, between the ages of 3 and 17 years. Creatinine values are related to sex, age, height, weight, surface area, calories per 24 hours, and the breadths of muscle, fat and bone as seen in x-rays of individual children. Results may be summarized as follows:

1) Mean creatinine excretion during this age-span ranges from .33 gm. at 4 years to 1.85 gm. at 16 years for boys, and from .31 to 1.26 gm. for girls.

2) Curves for mean creatinine excretion and mean body weight show similar patterns.

3) Norms are given for the creatinine/body weight ratio, or *creatinine coefficient* (mg. creatinine excreted in 24 hours per kg. of body weight). Values rise in boys from 20.9 at 4 years to 27.0 at 16 years, while for girls the means rise from 18.9 at 4 years to 25.5 at 10 years, then fall to 21.9 at 16 years.

4) Boys and girls show about the same mean daily creatinine excretion per unit of body weight, disregarding age, between 10 and 50 kg. of body weight. From 50 kg. on, boys show an increasingly greater creatinine excretion for their body weight.

5) Creatinine excretion shows a closer association with body weight than with body height.

6) Two-thirds of the individual creatinine/body weight ratios lie between 19.0 and 28.0. Less than 10 percent of the values are less than 16 or more than 34.

7) Almost three-fourths of the creatinine/body weight ratios show a maximum difference of 7.5 or less, between values obtained on a child at one period, and values obtained at a time six months or a year later. Around 7 percent show maximum differences of more than 13.5.

8) A series of 25 children, representing 66 creatinine determinations, were selected for further analysis, on a basis of showing the least variability in the creatinine/body weight ratio. In this series, the boys are on the average 8 months younger, and slightly smaller in weight, height and surface area, but have higher values in creatinine excretion, the creatinine/body weight ratio, and calorie output per 24 hours.

9) Boys in this series are slightly smaller in mean total breadth of calf, as seen in the x-ray, and smaller in relative breadth of fat, but larger in relative breadths of muscle and bone.

10) Intercorrelations (r) are shown for 7 variables on these 25 children: creatinine excretion, age, weight, height, and the breadths of muscle, fat and bone. All associations are +.75 and above, except as follows: fat breadth shows relatively low coefficients (+.42 – +.65) with all the other variables, while age shows an r of +.59 with muscle.

11) Creatinine appears to be more closely associated with muscle breadth, as here measured, than with bone breadth, and shows little association with fat breadth.

12) A group of children, rated by clinical inspection as strongly muscular, were compared with a group of non-muscular children. The former group showed a significantly higher creatinine/body weight ratio.

13) The association of creatinine excretion with surface area and with calories per 24 hours is high (+.91 in each instance).

14) Analysis of an additional series of 150 creatinine determinations, based on urine samples collected in the fall of 1947, shows results which agree with those summarized above.

15) A more detailed analysis of both creatinine and creatine determinations on these same children, together with a report on other biochemical variables, is in preparation.

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FURTHER DATA CONCERNING THE NORMAL VARIABILITY OF THE MENSTRUAL CYCLE DURING ADOLESCENCE AND FACTORS ASSOCIATED WITH AGE OF MENARCHE

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and

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For the past ten years the Mooseheart Laboratory for Child Research, in cooperation with the Mooseheart Hospital, has kept careful records concerning the menstruation of the female adolescent population.[2] As the average Mooseheart girl remains in the community from the time of admission, which is usually before puberty, until graduation from high school at the average age of 18.5 years, it has been possible for the Laboratory to obtain objective records of the menstrual cycles of these girls for approximately five years during the adolescent period. The first paper in this series appeared in 1940 (16).

The intra-individual variability of the menstrual cycle has been demonstrated by a number of workers in the past fourteen years (1, 2, 4, 5, 6, 10, 12, 13). In a comprehensive review of the recent work, Arey (2) reported on the investigations of Allen (1), Engle and Shelesnyak (4), Fluhmann (5), Gunn, *et. al.* (6), Hartman (10), King (12, 13) and others, comparing these more recent findings with reports of some of the earlier investigators. According to Arey (2), most of the normative data on length of menstrual cycle and duration of flow reported prior to about 1933 can be questioned on the basis of the subjectivity of the sources of information. That is, most of the early data consisted of verbal reports of patients regarding their own menstrual cycles rather than objective records. The apparent result of this subjectivity was to obscure the considerable variability in the menstrual activity of most women, which the recent and more objective investigations

[1]The senior author is indebted to his research associate, J. Warren Thiesen, Ph.D., for a final check on the manuscript.

[2]Mooseheart, the City of Childhood, is operated by the Loyal Order of Moose for the children of its deceased members. Entire families may be admitted to the community upon the death of the father, each child remaining until graduation from high school at the average age of 18.5 years. Since the community has been set up to meet the needs of normal children and was not designed to deal with the handicapped individual, the population consists of children who are normal physically and mentally in terms of meeting certain definite standards. Geographically, they are a representative sample of the national population, being drawn from all states of the Union, and they range in age from birth to approximately 19 years.

have demonstrated. For example, as late as 1933, Kennedy (11) classified 10,219 hospital patients according to the reported lengths of their menstrual cycles in days. Recognizing the subjective factor, Kennedy made allowance for one- to two-day variations from these reported individual means, but classified individuals reporting greater variability as "irregular" and considered them atypical. A number of somewhat similar studies, based on the subjects' introspections and recall, which we shall not attempt to review in this paper, are discussed by Arey (2), and their conclusions associating normal function with precise regularity are contrary to the recent and more objective evidence regarding the variability of the normal menstrual cycle.

Since the findings of the present analysis are given under several subdivisions representing different aspects of the problem, comparisons of these findings with those of other workers will be made by citing appropriate references under the several headings.

Method

The first and last day of the first menstrual period and of each succeeding period were recorded for each girl in the population. A statistical analysis was made of the durations and certain correlates of 5,562 menstrual cycles of 100 girls drawn from this population. The analysis was based upon a period of time extending from the menarche until graduation. Both group and individual variation of the menstrual cycle was investigated. The term "cycle" has been defined, for the purpose of these investigations, as the length of time from the beginning of one menstrual flow to the beginning of the next. The term "period" designates the duration of flow.

Relationships of the durations of cycles and periods and their variability to such factors as age at time of menarche, season of menarche and time elapsed since menarche, and also correlations between siblings' ages of menarche were investigated by comparing the data obtained from certain subdivisions of the total group among which these factors varied. Conventional statistical procedures were used, including computation of means, standard deviations and modes of cycle and period durations in units of days. Differences in these values associated with the variables under investigation were tested for statistical reliability by means of Fisher's "t test," based on Student's distribution.

Results

Length of the menstrual cycle:

Figure 1 shows the distribution of 5,563 M[3] cycles recorded on the 100 girls in this study. Their age range was from 10 to 18.5 years. This curve is similar to others reported in the literature (1, 2, 3, 4, 5, 8, 10, 12, 13 and 17) and approximates a normal distribution but tends to be leptokurtic and positively skewed. The cycles varied in length from 10 days to 250 days.

[3]M is used as abbreviation for menstrual.

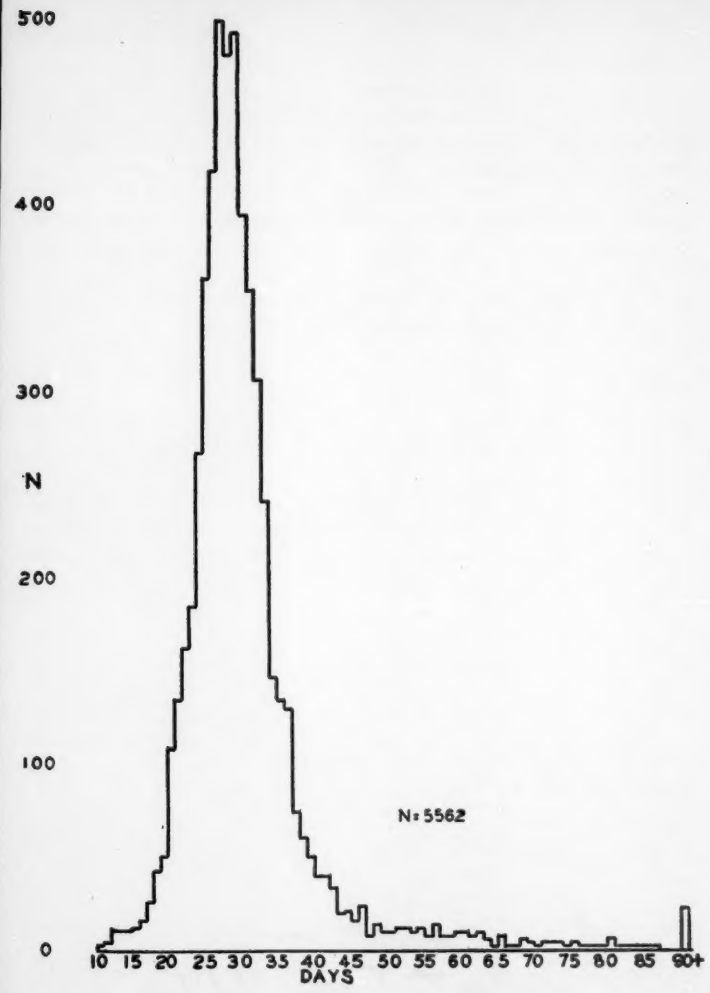

Figure 1

Frequency distribution of lengths of 5,562 Menstruation cycles on 100 girls ages 10 to 18.5 years. Mode 27 days. Mean 29.77 days. Standard deviation 8.11 days.

The mode of the distribution was 27 days and the mean 29.8 days. The standard deviation was 8.1 days.

Monthly variability in the length of the menstrual cycle:

Engle and Shelesnyak (4) reported a greater frequency of "long" cycles in the summer. These were designated as temporary amenorrhea. Hartman (9) found that the ovulation of monkeys was inhibited during the summer months. Knaus (14) reported that the M interval was shorter in the winter than in the summer. Bjornsson (3) repeated this work by counting the number of M periods per month and was unable to find any seasonal difference.

TABLE 1

Critical ratios between winter and summer months.
Length of menstruation cycle in days.

Months	*C.R.*	*Probability*
Oct. – May	1.86	——
" – June	3.05	.01
" – July	3.76	.01
" – Aug.	3.96	.01
" – Sept.	2.50	.05
Nov. – May	0.97	——
" – June	2.10	.05
" – July	3.04	.01
" – Aug.	2.68	.01
" – Sept.	1.38	——
Dec. – May	1.79	——
" – June	2.78	.01
" – July	3.76	.01
" – Aug.	3.47	.01
" – Sept.	2.26	.05
Jan. – May	1.50	——
" – June	2.68	.01
" – July	3.63	.01
" – Aug.	3.32	.01
" – Sept.	2.14	.05
Feb. – May	3.66	.01
" – June	4.62	.01
" – July	5.42	.01
" – Aug.	5.25	.01
" – Sept.	4.18	.01

Our data, which are summarized in Figure 2 and Table 1, show a definite seasonal variation in the M cycle. The length of the cycle varied from

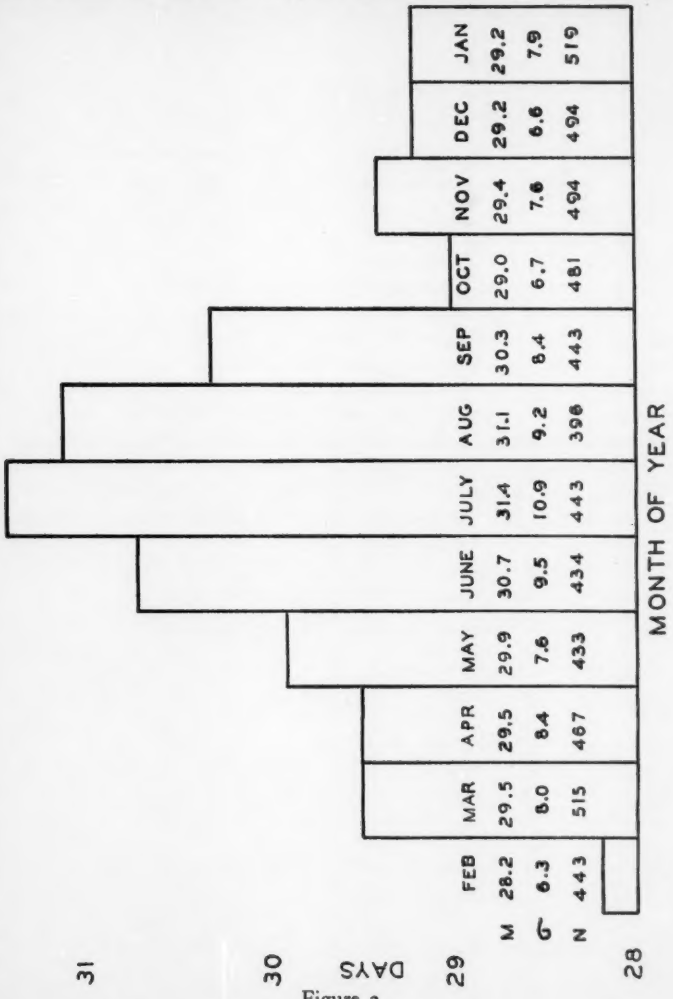

Figure 2

Monthly variability in the length of the menstruation cycle of 100 girls ages 10 to 18.5 years. M – is the mean. N – is the number of cycles in each month. σ – is the standard deviation in days for each month.

an average of 28.2 days in February to 31.4 days in July. The reliability of the difference between the winter and summer months is reported in Table 1. It should be noted that the differences between the very cold and the very warm months are all at the .01 level of significance. Perhaps the reason that Bjornsson did not find these differences is because of the grossness of his measure; merely counting the number of cycles per month might abscure any real differences which would be apparent under more refined analysis.

Length and variability of the menstrual cycle in relation to age:

The findings of the present analysis are very similar to those reported by Arey (2). He found that the average length of the M cycle was 33.9 days for girls and 29.5 days for women. He also reported that the girls were much more variable in the length of the cycle than were the women. Figure 3 presents our data in graphic form. The lengths of M cycles during the first year after menarche were found to have a higher mean than those during the fourth to fifth year of menstruation. For the first year the mean length of the M cycles is 32.01 days. In the fourth and fifth year the mean length is 29.03 days. However, this mean difference is apparently the result of a pronounced and substantial positive skewness in the first year curve. This skewness gives a higher mean. The frequencies beyond 58 days probably indicate "skips" or irregularity in function. Hence, conclusions regarding average length of interval need to be qualified in the light of the irregularity or "skips" in the first year. More suitable measures of central tendency in this situation are the median or the mode, which are not greatly weighted by the presence of occasional "skips." The modes of the two groups are equal as are the medians.

As a result of the skewness in the first-year curve occasioned by more frequent missing of periods, the variability in M cycle length is much greater in the first year of menstruation than in the fourth to fifth year, the standard deviations being 11.9 days and 5.9 days respectively.

Our most accurate conclusion, then, is that the length of the cycle does not vary so much with age as does the regularity. There is a greater tendency toward missing periods during the first year than later on.

TABLE 2

Mean difference in age of menarche between sisters and unrelated group.

	N (Pairs)	*Mean Difference in Months*	*Sigma*
Sisters	72	10.61	8.24
Unrelated	200	13.89	11.80
	t=2.17	P=.025	

Familial tendency in age of menarche:

Gould and Gould (7) report that there is a relationship between the ages of menarche of mothers and daughters as well as between sisters. They do not report the reliability of these findings, however. Table 2 shows the findings of the present study. The means and sigmas of the differences, in months, of the ages of menarche of 72 pairs of sisters as compared with 200 pairs of unrelated girls are given. It was found that the mean difference, in months, for the sister group was 10.6 and for the unrelated group, 13.9. A test of the significance of the difference between the means of these

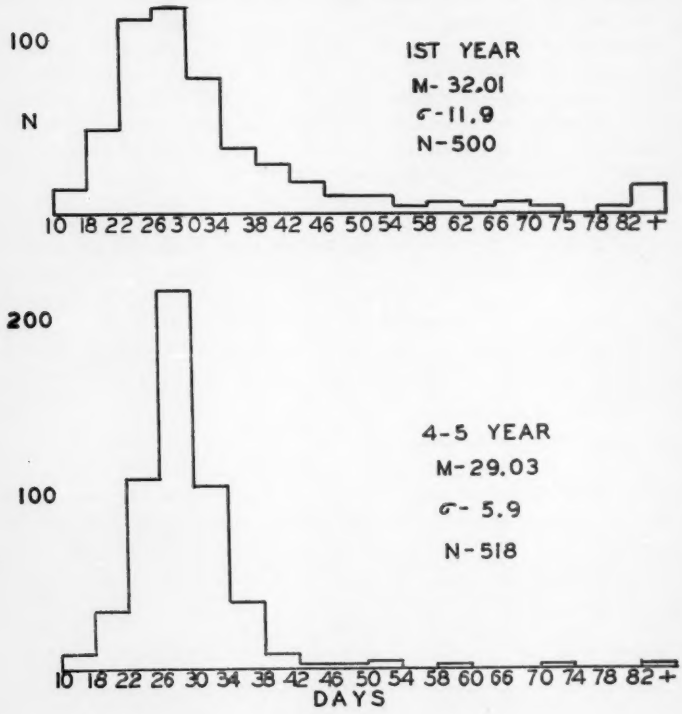

Figure 3

Length and variability of menstruation cycle during the first year after menarche compared with the 4-5 year of menstruation. M is the mean length of the cycle. σ is the standard deviation of the total group in days. N is the number of cycles measured.

groups based on Fisher's "t test" yielded a value of "t" of 2.17, indicating a probability of .025 as the chance expectancy of such a difference. From our findings and those of Gould and Gould it may be concluded that a genetic factor seems to influence the age of menarche.

Month and age of menarche:

Engle and Shelesnyak (4) reported that there was a seasonal trend in the occurrence of the menarche. They found that fewer girls reached menarche in the summer than in the other seasons. The data obtained in the present analysis are at variance with these findings. A study of 261 cases of girls reaching menarche was made. There were two seasonal peaks in this function, one in the winter and the other in the summer. The incidence of menarche in fall and spring was lower. Age of the individual in relation to month of menarche was also investigated. It was found that relatively late menarcheal age was more frequently associated with the occurrence of menarche in winter or summer, while early menarcheal age was more often associated with occurrence of menarche in spring or fall. Figures 4 and 5 show this relationship graphically.

Individual variability:

An analysis of the individual girls in the study shows that the standard deviation of the M cycle varies from 2.9 to 12.9 days. This indicates that some of the girls were relatively regular in menstruation, while others were most irregular. Not one of the 100 girls was absolutely "regular." These findings are very similar to those of the summary study done by Arey (2) and are consistent with the findings of the previous investigation by Reymert (16).

Length of the menstrual period:

The length of the M flow varied from 1 to 14 days with a mean of 4.85 days and a standard deviation of 1.68 days. There was no seasonal variation in this activity. This is in line with other findings in the literature. Mc-

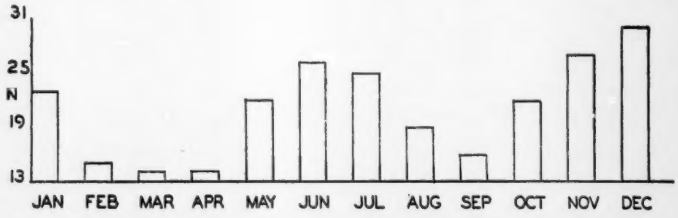

Figure 4
Distribution of number of girls reaching menarche in each month. Total N – 261. Smoothed curve.

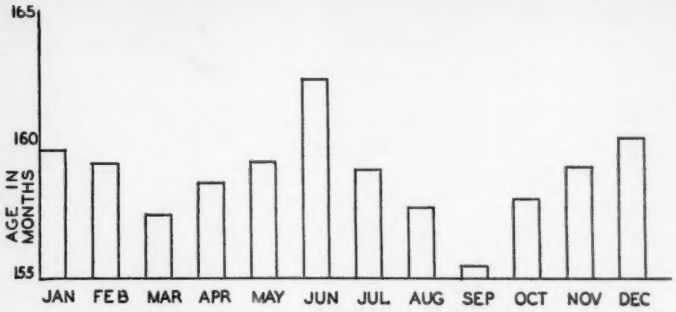

Figure 5
Distribution of average ages of girls reaching menarche in each month. Total N – 261. Smoothed curve.

Cance, *et. al.*, (15) found the mean period to be between 4 and 5 days.

Relationship of regularity and length of menstrual cycle to age of menarche:

The findings of this study concur with those of Engle and Shelesnyak (4) in that no relationship was found to exist between the length or regularity of the M cycle and the age of menarche.

Summary

1) The distribution curve of 5,562 menstrual cycles recorded from 100 girls from the age of 10 to 18.5 years approximates the form of a leptokurtic normal curve. The mode is 27 days, the mean 29.8 days, and the standard deviation 8.1 days.

2) A seasonal variation in the length of the cycle was found. The shorter cycles were found in the winter and the longer in the summer months. The length of the cycle varied from an average of 28.2 days in February to 31.4 days in July. The differences between the seasons were significant.

3) A seasonal difference in menarche was also found. More girls reached menarche in the summer and winter than in the seasons between. The girls reaching menarche in the summer and winter were also older than those reaching it in the other seasons.

4) Younger girls were found to have more irregular menstrual cycles with a greater tendency toward missing periods than older ones. The mean length of the cycle for the younger girls was 32.0 days and for the older ones 29.0 days; the difference between the means being principally a function of the higher incidence of "skips" in the younger group.

5) There seems to be a genetic factor influencing the age of menarche. The mean difference, in months, between the ages of menarche of sisters

was less than that of unrelated groups. The difference was significant at the .025 level.

6) The girls in this population varied considerably among themselves in regard to the regularity of the menstrual cycle. This difference ranged from a standard deviation of 2.9 days for the girl showing the most regular cycles to one of 12.9 days for the one showing the most irregular cycles. Not one of the 100 girls was absolutely "regular."

7) The length of the menstrual period varied from 1 to 14 days with a mean of 4.85 days and a standard deviation of 1.68 days.

8) No relationship was found between the length or the regularity of the menstrual cycle and the age of menarche.

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CASE HISTORIES OF FIVE THUMB SUCKING CHILDREN BREAST FED ON UNSCHEDULED REGIMES, WITHOUT LIMITATION OF NURSING TIME

FRANCES P. SIMSARIAN

On the basis of a study of numerous feeding histories Levy (3, 4) has concluded that the primary cause of finger sucking is insufficient sucking at breast or bottle. Statistics from his study demonstrate that the percentage of finger sucking problems is also consistent with the sucking time, rising as high as 40 per cent in infants fed at four hour intervals to as low as 6 per cent in unscheduled feeders. There was not one instance of finger sucking in the case of children who used pacifiers. Several children with rickets whose feeding histories showed sufficient sucking time did not develop the thumb sucking habit, thus ruling out the nutritional factor as a primary cause, according to the findings of Levy.

Roberts' (5) study of 15 thumb suckers and 15 non-thumb suckers confirmed the findings of Levy that the amount of time spent in sucking is the primary determinaant of the habit of sucking the thumb or fingers. Roberts found that in general non-thumb suckers took a longer time for feeding than was taken by thumb suckers. Eight of the thumb suckers studied by Roberts averaged less than 69 minutes of feeding in 24 hours during the first 7 - 8 months of life. No thumb suckers were found in the group which averaged more than 130 minutes of feeding in 24 hours during the first 7 - 8 months of life.

Davis (2), in using a questionnaire with 250 parents to explore the problem of thumb sucking found no thumb suckers among those children who were not kept to any schedule.

The five thumb sucking children whose feeding histories are described here were contacted during the course of a study of children fed on unscheduled or so-called self-demand feeding programs. The study included 26 children who had been fed on self-demand feeding programs in 20 different families.

At least five of these self-demand feeders were thumb suckers. In view of the fact that no specific questions regarding thumb sucking were asked during the course of the contacts with the parents it is possible that more of the group sucked their thumb or fingers. However, in view of the findings of the studies mentioned above, it was surprising to discover as many as five thumb suckers, or 19 per cent of this group of 26 children sucking their thumbs at some time during the first years of life.

The feeding history of case 1, the child of the writer, has been described in detail (6). The following is a brief resumé:

Case 1

A primipara, a boy weighing 9 lbs. 10 ozs. at birth. The infant was never placed in the nursery but retained in the hospital room with the mother. He was placed immediately on a self-demand schedule, the breast being offered first when he was about four hours old. During the first week of life he took a total of 54 breast feedings. Following this first week he gradually reduced the number of feedings. By the seventh week he took a total of 36 feedings. The number of weekly feedings varied slightly during subsequent weeks but there was no consistent reduction in the number of feedings until the 19th week when the infant was taking solid foods in addition to the breast feedings. The infant was allowed to nurse at each feeding until he indicated satiety by falling asleep or withdrawing from the breast. The amount of time spent in nursing reached a peak during the second week when the infant averaged 160 minutes of nursing during each 24 hour period. A gradual reduction in nursing time followed with marked variation from feeding to feeding. Single nursings lasting as long as 60 minutes were not unusual during the early weeks, but by the 12th week the average daily nursing time had been reduced spontaneously to 88 minutes in 24 hours. No detailed records on nursing time are available after the 12th week.

Bottle feedings of milk were introduced during the sixth month and there was a gradual weaning from breast to bottle feedings from the sixth to ninth months. Similarly weaning from the bottle was gradual; the last bottle feedings were abandoned by the infant during the 17th month.

Significant about the early feeding history was the fact that the infant gained weight regularly but not rapidly. He lost to 8 lbs. 13½ ozs. on the fifth day, regained his birth weight on the 19th day and weighed 25½ lbs. at the end of the first year.

Thumb Sucking

The obstetrician observed that the infant sucked his thumb shortly following birth. Thumb sucking was persistent throughout the first three months of life, then spontaneously ceased during the fourth month. The child, now seven years of age, has never returned to the habit and has never sucked other fingers nor objects. During the early days following birth the infant lacked sufficient co-ordination to obtain and retain the thumb and involuntary losses often resulted in crying. He preferred the prone position and in this position was better able to secure the thumb. An attempt was made to use a pacifier but it was usually lost quickly and the infant of course was unable to retrieve it.

Discussion

The fact of the thumb sucking as well as the fact of its dramatic cessation is of interest in this case. The thumb sucking occurred during the early weeks of life when the infant was taking many more than the traditional number of feedings and averaging even up to 160 minutes of nursing time in 24 hours. The thumb sucking was spontaneously abandoned at a time when the infant also made marked spontaneous reduction in the amount of nursing time. The record of weight gain and loss leaves room to question whether the infant may have been slightly underfed although no evidences of undernutrition were noted on regular pediatric examinations. Also the weight gain was highly regular. It is notable also that Levy found cases where children suffering from rickets did not develop the thumb sucking habit.

Case 2

A primipara, a girl. This infant was on 4-hour scheduled breast feedings during a 10-day hospital period. She was first placed at the breast when she was about 24 hours old. After an unsuccessful attempt to keep the infant on scheduled feedings during the first days at home the mother gradually changed to unscheduled feedings. When first placed on unscheduled feedings, the infant is reported to have demanded feedings every two and a half to three hours during the day time and somewhat less frequently at night. She began to sleep through the early morning feeding by about the eighth week. The

mother recalls that the infant always nursed rapidly. Reportedly, she rarely if ever took longer than 20 minutes to complete a feeding. She was always allowed to nurse until she indicated satiety. She weaned readily from the breast to the cup during the eighth and ninth months. She was given occasional bottle feedings during this time but gave no evidence of prefering the bottle.

Thumb Sucking

Thumb sucking began during the second to third month. The mother reports that it was associated with distress following eating, that the infant sucked her thumb as if in distress and frequently choked herself with her thumb causing regurgitation of the milk. Thumb sucking occurred at other times also and was sufficiently persistent to cause a blister to develop on the thumb. The mother never attempted to use a pacifier. During the infant's ninth month the blister on the thumb became sore and demanded medical attention. The thumb was bandaged for one night during which the infant was fretful and restless. Although the bandage was removed the following day the infant never resumed the thumb sucking habit. The child is now eight years old and has not returned to thumb sucking nor any allied sucking.

Discussion

In this instance also there was a dramatic cessation of the thumb sucking. It seems reasonable to speculate here that at least one cause of the thumb sucking was insufficient sucking due to a too rapidly flowing secretion of breast milk. The use of a pacifier would no doubt have been advisable.

Case 3

A boy, younger sibling of case 2. This infant was offered the breast first when he was about 24 hours old. He was placed on a program of non-scheduled feedings as soon as he was brought home from the hospital. He was a frequent feeder. His demands for feedings reached a peak during his third and fourth months of life when he often nursed at 2- to 3-hour intervals. The demand for frequent night feedings continued until after the infant was taking solid foods, into the fourth to fifth month. An attempt was made during the fourth month to supplement the breast feedings, but the infant refused to accept bottle feedings. He gained weight rapidly, doubling his birth weight of 6 lbs. 1 oz. during his second month. Weight gain continued rapidly and throughout infancy the child was a characteristically plump, placid baby. In contrast to his older sibling the infant nursed more slowly. The mother estimates an average nursing time of about 20 minutes although there were many individual nursings lasting longer. Difficulty was encountered in weaning the infant; weaning to the cup was not completed until the 13th month. Prior to this time the infant was taking milk from the cup but, according to the mother, "still coaxed to nurse primarily for comfort." He consistently refused bottle feedings.

Thumb Sucking

Thumb sucking commenced when the infant was weaned. Prior to this time there had been sporadic chewing or sucking of the thumb during periods of teething. Thumb sucking as well as sucking of objects was prominent for several years following weaning. It seems a correct statement to say about the child that at periods he always had something in his mouth. At the time of writing the child is six years of age. Thumb sucking has decreased markedly during the past two years but the child still resorts to it during periods of boredom or fatigue. He continues to have a happy, placid disposition. He is described by his mother as "unperturbable."

Discussion

In this case one is confronted with an infant whose demands for feedings almost exceeded the limits of endurance for a mother in our culture. Sucking for the sake of sucking continued far beyond the need for nourishment. The question arises whether

the infant sought and clung to the nursing experience as his only or primary source of contact with the mother. Observations of the home do not lead to this conclusion. The infant was given full measure of additional care and handling apart from the nursing situation by both mother and father. One is tempted then to speculate that this is a child with excessive need for oral gratification.

Case 4

A boy, the second child in the family. This baby was placed on non-schedueld feedings as soon as he was home from the hospital, in an effort to prevent the thumb sucking that had been prominent with the older sibling. The mother allowed unlimited nursings. According to reports the infant always required at least 20 minutes for a feeding and frequently took more time. The mother described night feedings when she fell asleep nursing the baby and he nursed for long periods. The infant never demanded frequent feedings, he rarely exceeded six daily feedings, and eliminated one night feeding when he was a few weeks old. By the time he was 3 to 4 months old he occasionally took only four daily feedings. His gain in weight was regular, he had doubled his birth weight by 6 months of age.

Thumb Sucking

Thumb sucking commenced when the infant was a few weeks old. At 6 months he was a regular and vigorous thumb sucker. The mother had never attempted to use a pacifier. The mother commenced a gradual weaning to bottle feedings at 6 months. It has not been possible to obtain further history on this infant.

Discussion

One is confronted here with an infant who made a rapid reduction in the number of his feedings, but prolonged the nursing time at least on some occasions. He made this reduction in the number of feedings despite a somewhat slow gain in weight, turning to his thumb rather than to additional or still further prolonged feedings for the extra sucking which he apparently needed.

Case 5

A primipara, a boy, weighing 7 lbs. 13 ozs. at birth. He was placed on non-scheduled breast feedings when he was brought home from the hospital on the 13th day of life. For the most part he rarely demanded more than five daily feedings, but occasionally received as many as eight daily feedings. In general he nursed rapidly, often during the early weeks regurgitating some milk during a feeding. There were occasional nursings during the early months lasting as long as 30 to 45 minutes. The infant gained weight rapidly, doubling his birth weight by two months. Because of the rapid gain in weight occasional attempts were made to limit the number of daily feedings but the mother slipped back after a few days or weeks to non-scheduled feedings. The infant was weaned gradually from breast to bottle and cup feedings. He nursed partially at the breast until into the 10th month of life.

Thumb Sucking

Thumb sucking commenced during the third month of life and at the time of writing is still perisistent although gradually diminishing. The infant is 3 years of age. Thumb sucking occurs now during periods of fatigue or at bed-time. The mother has never used a pacifier. There has been no observable relationship between the onset nor the intensity of thumb sucikng and any change in the feeding program.

Discussion

It seems likely that in this case, as in case 2, that the infant received too little sucking at the breast to meet his needs due to a rapidly flowing secretion of breast milk, and hence turned to thumb sucking.

Summary and Conclusions

The feeding case histories of five thumb sucking children breast-fed on self-demand feeding regimes without limitation in nursing time have been discussed. Each of these children presented a different feeding history and the thumb sucking picture was similarly different in its onset, intensity and persistence. Two of the thumb suckers studied were siblings, another had an older sibling who also sucked her thumb. This latter child, however, was not fed on a self regulating feeding regime. The other two thumb suckers considered subsequently had younger siblings, neither of whom was a thumb sucker, thus ruling out any ready conclusion that thumb sucking inevitably runs in families.

The fact that these five thumb suckers appeared in a study of only 26 self-demand feeders, and that they therefore represent 19 per cent of the total sampling, is subject to the criticism that the total sampling of cases is small. Such a high percentage of thumb suckers in a group of self-demand feeders might never again appear. It should of course be recalled at this point that Levy did find a 6 per cent incidence of thumb sucking in his larger group of unscheduled feeders. The facts presented leave one no alternative but to conclude that whatever the cause or cure of thumb sucking, self-regulated feedings without limitation in nursing time are no complete panacea.

This conclusion finds substantiation in an article by Bragman (1) in which he discusses instances of thumb sucking as portrayed in art; thus pointing up the fact that thumb sucking apparently occurred in cultures where, as far as we know, all children were fed on self-regulating schedules and permitted unlimited nursing time.

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PHYSIOLOGICAL FACTORS AND PERSONALITY IN CHILDREN[1]

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One aspect of the study of individual differences in children which we feel is tremendously important is an appraisal of differences in physiological behavior in response to stress. I use the term stress to include any environmental impact or stimulus, either exogenous or endogenous. The running of the 100-yard dash is, therefore, an example of a physical stress. The initial efforts of a parent to condition a 6-or 7-months-old infant's bowel action is also a stress situation for the infant, in this instance what might be called an emotional stress.

The effort of the parent to make the growing child conform in his increasing social and physical contacts to a pattern which is acceptable and not too disturbing to the parents is in reality the application of a whole battery of successively applied stresses to which the child reacts, not only in terms of overt behavior but also with greater or lesser degrees of change in various aspects of body function. The infant who is too abruptly weaned reacts to his frustration not only with anxiety, irritability, and hostility; but also very probably with changes in the peristaltic rate of his intestine; in the vascularity of his kidneys and therefore their rate of excretion; in changes in heart rate, blood pressure, perspiration, and in many other ways. The birth of a little brother or sister into the family may create a very important stress situation for a child, as may entrance to school, or having a fight with the little boy down the street.

The whole social and emotional adjustment of the child is accomplished through a series of environmental stresses or impacts, and in response to each of these stresses there may be a greater or lesser degree of modification of many of the biochemical and physiological processes of the body; changes which may be momentary or very prolonged in their nature. They are an integral and highly important part of the behavior of the child as a whole organism in his life situation. They cannot be dissociated from other aspects of his behavior. A knowledge of individual differences in this somatic component of stress response is not only essential for an adequate understanding of social behavior, but it is also essential to the medical man who is responsible for maintaining the health and physical effectiveness of the individual. Perhaps the posing of some of the questions which evolve from a consideration of this field will help you in grasping the scope and significance of an understanding of the physiological components of emotion in response to stress. For example:

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[1]Paper presented at a general meeting of the Society for Research in Child Development in Chicago, Ill., December 27, 1947.

1) Why do certain individuals exhibit an excessive distortion of the function of some of the organs of the body as a part of their anxiety or hostility response to stress? You have all seen children who in an apparently not too disadvantageous environment were subject to constantly recurrent gastrointestinal upsets of a non-infectious nature, expressed by vomiting or perhaps periods of two or three days of diarrhea. Such so-called psychosomatic manifestations are organ expressions of a disturbed emotional state. Why do such individuals express their disturbed state so heavily in terms of organ dysfunction while others may express it more in antisocial behavior?

2) To what extent does the life experience of the individual determine whether his reactions to a threatening environment will be excessively in terms of such organ dysfunction rather than in hostile or aggressive behavior toward parents or associates?

3) Is the selection of a given organ system for the expression of one component of emotional disturbance dependent upon what the use of that organ symbolizes to the child? One individual's emotional disturbance may be accompanied by vomiting, another's by diarrhea, another's by asthma. Do each of these various organ dysfunctions, as well as others, have some symbolic meaning to the individual? And is it for that reason that a given method of physiological expression is selected?

4) Are there inherited physiological capacities of organ systems which are the determinants of which system's function will break down in a given emotional situation? In other words, are people born with unstable stomachs or colons or vascular systems, and so express anxiety primarily through the so-called inherited weak system?

5) Is the nature and degree of organ expression of anxiety to be considered as an integral part of the total personality pattern of the individual? Does the passive person who tends to suppress the hostility he must have toward any threatening individual or situation have a characteristic pattern of organ response to stress?

6) Are there any linkages or relationships between the nature of the structure of an individual's body and the nature and degree of distortion of physiological processes in response to stress?

There are many and divergent opinions on all of these problems. The whole subject is currently of very major interest in the field of psychiatry as well as to students of child development, pediatricians, and others. Psychoanalytic literature refers occasionally to a constitutional factor as one possible determinant of the way an individual handles a frustrating, anxiety- or hostility-producing situation. Actually, however, analysts are usually inclined to explain such psychosomatic conditions as hypertension, colitis, constipation, asthma, etc., in terms of symbolism or as integral components of specific personality structure. The diarrhea of the colitis case is explained as a symbolic expression of hostility, a soiling with feces, as a substitute for the verbalization of resentment. The peptic ulcer case is presumed to

be a person with an excessive dependency need in conflict with his strivings for independence. Certainly it is true that in many instances in an individual suffering from such dysfunctions, one finds a life history and personality structure which are, to a considerable degree, in accord with such concepts. Nevertheless, one is always faced with the fact that there are many more individuals who, while comparable in life history and personality structure, do not manifest such symptoms of organ dysfunction.

At the Fels Research Institute in Yellow Springs, we are conducting a longitudinal study of the growth and maturation of structure and function of children. As a part of this study we are attempting to measure a number of physiological variables and their changes in response to stress. I think I should explain that by stress I mean one of two or three types of physical stress. Ideally, we should like to determine how an individual's physiological pattern changes in response to some anxiety-producing situation we might use. But it is very difficult to use any anxiety-producing situation which has the same meaning for any two individuals; therefore, the use, for example, of anxiety-producing motion pictures, or shock-avoidance learning tasks, etc. has been discarded in favor of such "physical" stresses as immersing a hand or a foot in cold water for a minute, or tilting an individual with his head down at a 45° angle for a period of 2½ minutes. Such stresses are more easily standardized and administered; and it is our belief that their effects are less commonly influenced by previous life experiences, etc. Yet, although they are physical stresses, they produce physiological response patterns and changes in such patterns which are almost exactly comparable to those resulting from visual or auditory stimuli.

The physiological variables which are measured before, during, and after such stresses include skin resistance, blood flow and blood flow variability by means of the plethysmograph, blood pressure, and heart rate and regularity. The selection of these particular variables is made on the basis of representation of as many organ systems of the body as possible and also upon the practical necessity of selecting such variables as are relatively easy to measure. Serial measurements of a number of blood constituents and metabolites excreted in the urine are also made, but are done under basal conditions and not at the time of application of stress.

The period of measurement is divided into three parts. The first period of relaxation lasts for 9¼ minutes. One of our measures is the change of the various variables which occurs during this rest period. There is then a period of stress which is 1 minute if the cold water immersion method is used, 2½ minutes if the tilt-top table is used. The change in the variables during this stress period is another factor measured. A 5-minute recovery period follows the application of the stress, and the degree of return to normal of the variables during this period is a third set of measurements which are taken.

Interruptions resulting from the war have set back materially our progress in the collection of data in this area; nevertheless, a few interesting results and leads are beginning to emerge from our work. One of these is that there appears to be a sex difference in physiological response to stress as measured on the tilt-top table. In a group of boys and girls ranging around 12 years of age, we found: 1) that girls exhibit more palmar conductance relaxation than do boys; 2) that girls exhibit a greater diastolic blood pressure relaxation than do boys; 3) that girls exhibit a greater physiological reaction to the stress in terms of palmar conductance and systolic blood pressure, but not in terms of diastolic blood pressure; 4) that girls recover more quickly in palmar conductance, systolic blood pressure, and diastolic blood pressure; 5) that girls adapt themselves less to the stress in palmar skin conductance than do boys. In summary, girls are not only more reactive to this stress than are boys, but they also relax more readily and recover more quickly from the stress.

The fact that sex differences exist in stress response patterns and that they are of a different magnitude in different systems suggests the possibility that part of the difference in incidence of such psychosomatic disorders as peptic ulcer and hypertension may have its foundation in such sex differences in stress response. A second interesting speculation is whether within each of the sexes the masculinity or femininity of the physiological response pattern tends to be associated with the masculinity or femininity of the personality. In other words, do passive, effeminate boys have a physiological response pattern more nearly that characteristic of girls and do aggressive, tomboyish, masculine girls have response patterns more nearly approaching those of the average boy? As yet, I can offer you no answer to this question. In certain other deviations of personality there are, however, strong suggestions of characteristic physiological response patterns. For example, the individual with the flat affect, whose contact with others is always poor, who lives primarily within himself has physiological response patterns very resistive to stress.

Another aspect of our study which was published by Dr. Jost and myself some time ago indicated that the autonomic patterns of individuals tend to approximate each other in accordance with the closeness of kinship. Monozygotic twins and triplets have autonomic scores which are very much alike. Those of siblings are much more likely to be similar than those of non-siblings and much less likely to be similar than those of monozygotic twins. Paired cousins resemble each other on the average much more nearly than do paired unrelated children, but less than do siblings and much less than do monozygotic twins. These findings, while not conclusive, suggest that the patterns of organ response of the individual are in part an inherited characteristic, subject to modification, of course, within the limits of physiological capacity of the individual.

In conclusion, studies of the physiological components of personality seem to be essential to a symmetrical expansion of an understanding of the total behavior pattern of human beings. A few interesting and significant facts are beginning to emerge from studies of this aspect of human development which are being conducted in various institutions in this country.

INFLUENCE OF METHODOLOGICAL FACTORS ON DOLL PLAY PERFORMANCE[1]

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Doll play is like clay modeling, painting, Rorschach interpretation and all the other varieties of projective tests; a child's performance carries an almost overwhelming aura of revelation to a sensitive observer. At first the child explores; like a rat in a maze or a man in a new house, he familiarizes himself with the physical details of his environment. He wants to know where things are, what they are made of, how they feel, and what they do. Then he reorganizes, shifting things this way and that, making the new world fit his preconceptions of what a world should be like. The living room goes *here* and the kitchen stove goes *there,* and this wall comes out and that chair stands closer to the table. It is not very different from a man entering his hotel room; the bellboy never fixes things quite right. Then, a little awkwardly, the youngster makes his first tentative efforts at living in this new world. He has been told he can do anything he wants in it, and he starts out with homely routines. There are people here, family people, and he knows what is customary. Mother cooks at the stove, daddy reads a newspaper in the living room, the children take a bath and go to bed. All this is very safe and very understandable.

But suddenly the observer realizes there has been a change, not a quick or easily detectable one, but one that has taken several minutes and has just now reached the observer's threshold. The child is more intent on the dolls, less reactive to the observer, and he is living strangely in this new fantasy world. He begins to tell stories that have no immediate parallel in his real life; he makes the family people behave as family people virtually never do. There are fantastic punishments and catastrophic accidents, social roles are reversed, and a few routines like toileting may exclude all the rest of ordinary everyday activity.

And then the observer has a feeling that blinds have gone up, and he is seeing the inner person of this child. It is as if the child were making him see this family world as the child himself sees it—or, perhaps, as he would like to see it. There are nuances and subtleties that cry out for interpretation. For instance, I saw a 6-year-old boy whose pediatrician referred him because of evident signs of anxiety and tension. The mother reported no conflicts between herself and her husband, but her manner left me skeptical. The boy's doll play during two half hour periods contained only one brief instance of social interaction between the father and mother dolls.

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[1]Paper presented at a general meeting of the Society for Research in Child Development held in Chicago, Ill., December 27, 1947.

All their other behavior was stiff and parallelistic. That kind of doll play is rare in normal 6-year-olds, and it was a temptation to assume that my suspicion of marital discord was correct, that the boy saw his parents as never coming together.

This way of thinking about the manipulative activity of doll play is very seductive. It offers an open sesame, a kind of psychological X-ray, into the motivational systems of very young children—and in all the field of human behavior, there is no darker cavern more in need of illumination. But much as we may need new devices for entering this great unknown, we need validation and objectification of measurement more. Are such interpretations true? Was this child really seeing his parents as cold isolates, prowling separately and dangerously through his gloomy life? A comment of Titchener's seems suspiciously apt: "The wish is father to the thought, and the thought is but the wish become dogmatic." The ambiguous character of children's play can be a dangerously fertile stimulus to the projection of our own interpretative predilections.

Another source of potential error lies in the failure to evaluate properly the influence of variables that are irrelevant to the personality of the child. If an investigator's main concern is with a youngster's motivational systems, his habits, or his perceptions of the environment, care must be taken that the investigator's own procedures do not determine the performance in unknown ways. To guard against such danger, he must discover *all* the conditions that produce different kinds of performance.

At our present primitive stage of understanding, these conditions can be lumped under two main rubrics. The first is *methodological* and the second is *experiential*. The methodological variables are those the investigator controls himself, the stimuli and manipulanda he provides for the child. The experiential variables are those of the child, the stimuli that have acted on him, the experiences he has had, the roles he has played. It is these latter relationships in which a researcher on childhood personality is ultimately interested, but if doll play is to be used as a measuring device, the methodological factors may not be ignored, for it is they that largely determine the constants in doll play performance. It will be well, therefore, to examine the available research data with a view to discovering how much and in what ways methodological variation influences the play.

Recording and Measuring

There are various ways in which the doll play performances can be recorded or measured. Four main procedures have been reported so far. The first, perhaps best characterized by the work of Conn (3), Despert (4), and Lerner and Murphy (7), places emphasis on a qualitative description of thematic content. The second, exemplified by Erickson's work (5), involves analysis of the ways in which the child organizes his materials. The third, a quantitative method devised by Bach (1), provides a set of carefully

defined content categories which are used for behavior unit recording. It differs from the earlier methods in that its categories represent certain psychological abstractions, such as *aggression, affection,* and *tangentiality,* rather than common sense descriptions of behavior. While this procedure reduces the personalized character of a report of a child's doll play, it achieves the important goal of permitting quantification and, hence, comparison of one group of subjects with another (cf., 11). The fourth method, used by Pintler (9) and others (2, 8, 10, 12), is essentially a modification of Bach's, but with partial application of time sampling in place of behavior unit recording. This eliminates certain statistical problems but also decreases the sensitivity of the measurement somewhat.

Recording and measurement seem to develop by the cut and try method. Attention must be devoted to the kinds of concepts into which the raw play is converted, and to the quantification of the observed behavior. The present techniques leave much to be desired in respect to the cogency of the measures obtained, but they do permit crude quantitative comparisons of the effects of different doll play methods.

Materials

There are many ways in which the experimenter can vary the presenting of materials to the child. The first problem lies in the nature of the materials themselves. The dolls and doll furniture can vary, for example, in ***degree of realism.*** Phillips (8) compared the performance of two groups of twenty preschool children presented with different types of furniture. One set was very realistic and contained much of the furniture to be found in a small middle-class home. The other set was composed of the same number of pieces, but the units were wooden blocks of various shapes and sizes, and bore only a vague and ambiguous resemblance to furniture. During an hour of doll play, the children presented with realistic furniture and dolls explored their materials much more than did the other group, but spent much less time organizing the doll house. The realistic materials also led to more continuity in thematic content; there were fewer theme changes. However, if one were interested in studying children's organizing behavior rather than the thematic content of their play, it is evident that the ambiguous, unrealistic materials would better serve the purpose. The differences here are similar to those between the ambiguous Rorschach blots and the relatively meaningful Thematic Apperception pictures.

Another variable, the ***degree of initial organization of the materials,*** has been studied by Pintler (9). To one group of twenty preschool children, realistic materials were presented in organized form. To a second group, the materials were presented in unorganized form, as in the Phillips study. It is hardly surprising, of course, that the latter group spent much more time in organizing activity. Again the implication is clear that the methodology determines how much organizing behavior the observer will have an opportunity to observe. However, an observer primarily interested in the-

matic content will see more of that if he organizes the furniture into household form in advance. In the course of an hour's observation, too, he will observe more instances of thematic aggression and aggression will occur earlier in each session. There is some indication, too, that the organized materials lead to more nonstereotyped play, that is, to the individualistic and imaginative actions that depart from the routines of real life. Some of this is accounted for by fantastic forms of aggression, but not all of it. There is also more role reversal.

Neither of these two variables, *realism* or *initial organization,* has any detectable effect on the amount of time the child spends on such routine thematic play as getting dinner, going to bed, bathing, or playing in the living room. Nor is the amount of tangential behavior influenced; the child sticks to his dolls as well under one condition as another.

Another aspect of the materials is the extent to which they provide *fantasy support* or stimulation. The setting provided for the child's play can apparently vary in its effectiveness as an instigator to thematic play. If the fantasy environment contains few objects to which the child has ready-made fantasy responses, his play seems to lack the thematic variety it has in an environment containing more such stimulation.

No fully controlled investigation has been devoted to a test of this supposition, but two recent studies have given it indirect support. In a study of sex differences, Bremer (2) compared the effects of two fantasy environments, one a household setting and the other an outdoor or yard setting. Both set-ups were made of stiff cardboard and all but one or two pieces in each were glued down. The same dolls were used with each, and the same children were presented with both settings. It seemed to Miss Bremer and me that the yard, containing fewer objects than the house and none of the conventional toys (except a sandpile, slide and swing) such as children usually play with outdoors, was significantly less stimulating to ready-made play themes. This is a matter of sheer judgment, however, and some other interpretation might better account for the differences obtained. The yard setting produced substantially more aggression, particularly of a tangential, nonthematic type. The children seemed to be frustrated by the doll play, and turned toward the experimenter to express their annoyance. They also showed more nonaggressive tangentiality with the yard setting.

In another study, Jeffre (6) used only two dolls, mother and child, instead of the full family used by Phillips and Pintler. The setting was organized and realistic. Jeffre obtained only a third to a half as much thematic play as the other investigators; likewise, as in the Bremer study, there was a high incidence of tangential aggression, particularly toward the materials themselves.

Neither the Bremer nor the Jeffre experiment gives critical evidence on the influence of fantasy support, but both suggest that a lack of such stimulation reduces thematic content and increases tangential aggression.

A fourth aspect of the materials that influences performance is the *doll family constellation.* One common assumption on which the use of the term "projective" is applied to doll play is that the child identifies himself with one of the dolls, and interprets the other dolls as being his family or associates. Most investigators appear to have tried to further this identification to some extent. It might be supposed that the process would be facilitated if dolls were used that exactly represented the child's own family or associates. Robinson (10) tested this assumption by presenting one group of 25 preschool children a duplicative doll family; and a matched group, a standard family composed of father, mother, boy, girl and baby. All the children were from one- or two-child families. Measurement of the doll play was similar to that used by Phillips and Pintler, but a record was also kept of the frequency of signs of identification and of the agents and objects of thematic aggression. The signs of identification included all activity or verbalization that related the child or his family to the materials or to a theme. Robinson found that 37 of the 50 children showed such signs at least once, but there was reliably more frequent occurrence of them in the group presented with the duplicative doll families. These children also showed somewhat more aggression toward the mother doll and toward the doll that represented the subject himself.

The importance of this difference is suggested by an analysis of the correlates of identification. In general, it appeared that a high amount of identification was associated with a low amount of aggression, as if acknowledgment of the "realness" of the doll play situation made the child act more "real," i.e., more temperate, in his expression of aggression. The converse relationship, low identification and high aggression, did not hold, however; all degrees of aggressiveness were observed among the youngsters with low identification scores.

If identification is of importance, the use of the duplicative doll family appears to be one way of securing it without risking the consequences of direct suggestion. Bach (1) found that such verbal suggestion created resistance in some children, and that these non-identifiers gave evidence of greater inhibition of aggression later in the doll play sessions. His procedure differed from Robinson's in that he directly suggested identification, while Robinson simply provided the fantasy support for it without herself entering into the stimulation.

Experimenter-child Interaction

Although play therapists have been deeply interested in the relationship of the child to the therapist, little is known of the effects of different methods of interaction. There are various ways of presenting the situation to the child. Bach's findings, cited above, indicate that the direct suggestion of identification may tend to create a withdrawal and a generalized inhibition of play. By trial and error most investigators have found that a

quiet, non-intrusive approach leads to the quickest involvement of the child in play.

Once play is under way, the experimenter has various choices. He can sit passively, appearing not to notice the child, or he can notice the child but interact very little, or he can be actively interested and be very responsive to what the child is doing; in addition to these variations, he can be general or specific in urging theme elaboration and can even attempt to secure from the child, or give himself, interpretations of the play.

One attempt has been made to discover the effects of these different procedures. Pintler (9) used a low level of interaction with one group of twenty preschool children and a high level with another. The low level included only rapport-maintaining remarks and stimulation to stay in the situation, i.e., control of tangentiality. There were no more than five such interactions between child and experimenter in each 5-minute period. The high level procedure involved 15 to 20 interactions per 5-minute period, and included generalized stimulation toward thematic play.

The high level of interaction produced very considerably more individualized thematic play and more different themes during the play sessions. It also led to a higher incidence of thematic aggressive actions and a shorter latency period before the appearance of the first aggression. The low level of interaction produced, or perhaps more correctly, permitted, somewhat greater tangentiality. The amount of routine thematic play did not seem to be influenced by these variations in method of interacting.

Duration of Session

Still another factor that the experimenter can vary almost at will is the duration of the doll play session. The effects of play are cumulative in various ways, and the nature of the child's performance during any given period is in part a function of what experience he has had before. For example, there is ordinarily a latent period before any aggression occurs. The child appears to need this time to test the experimenter's tolerance of aggression. When he finds no retribution, he exhibits hostility with progressively greater freedom. During a half hour of play, there is a continuous increase in frequency of aggressive acts if these are charted for successive five-minute intervals. Thus an average frequency per unit of time for a 15-minute period will be less than one for a 30-minute period (11). Similarly, exploratory and organizational behavior are, in the main, reactions to the newness of a situation, and are concentrated in the first few minutes of play. The relative amount of such activity is inevitably a function of how long the child plays.

In the study by Phillips (8), comparisons were made between the play of two groups of preschool children, one of which had a full hour of consecutive play and the other of which had three 20-minute sessions spaced through a week, no two sessions ever occurring on consecutive days. That

there proved to be more exploration and organization in the hour composed of three short sessions than in the continuous hour is not surprising; to some extent the situation was a new one each time a child had been away from it for 48 hours and then returned. Comparisons of frequency by 20-minute intervals showed no difference between the groups in the first 20 minutes, but reliably less exploration, during the other two periods, for the continuous hour group.

There was fairly clear indication that the long lession was more frustrating to the children than was a series of three short sessions. An hour is a long time for 3- and 4-year-olds to concentrate on one activity. There was more tangential behavior toward the end of the continuous hour group, and, too, tangential aggression increased slightly.

In general, the long session appeared to tax both child and experimenter. What it saved in time, that would otherwise have been devoted to repetitive exploration, was expended in increased tangentiality rather than in productive thematic play. Tangentiality may sometimes be a sign of anxiety, but more often it is associated with fatigue and boredom. If an investigator is intent on securing thematic material, the child's constant withdrawal from the task is not only a nuisance but disrupts the flow of play and quite possibly keeps the child oriented more to realistic matters than to his own fantasies.

Conclusion

These methodological facts are hardly exciting. They do not contribute in any direct way to an understanding of how doll play may be used for analyzing sibling rivalry, repressed hostility, the roles of family members, or intrapersonal conflicts. They are simply the necessary brush-clearing and hump-leveling required before we go on to erect a structure of facts and theories that will relate to the *experiential* determinants of doll play behavior.

There is still much to be done. The experiments that have been summarized here have dealt with a narrow range of variation. Materials can vary in many other dimensions than those which have been studied; they can include life-size dolls, for example, or environmental gadgets covering a much wider range than the household or school settings that have been reported here. The experimenter-child relationship has been barely touched; the whole field of interpretation is yet unexplored, and there is no sound information about the effects of different devices for anxiety reduction.

However, the variables so far examined will aid in establishing bench marks for methods that can at least provide comparable data from one experimental situation to another. And if we are eventually to discover procedures by which the experiential representation can be isolated and understood from the child's projective play, these basic constants must be provided.

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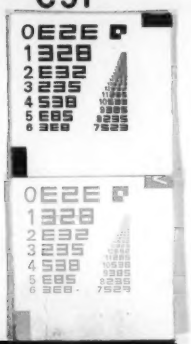
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